Phys 131
Fall 2015

Fundamental Mechanics: Class Exam II

8 October 2015

Name: _____ **Total:** /70

Instructions

- There are 7 questions on 6 pages.
- Show your reasoning and calculations and always justify your answers.

Physical constants and useful formulae

$g = 9.80\,\mathrm{m/s^2}$

Question 1

A 40 kg crate is initially at rest on the ground. It is then raised vertically by a rope which exerts a constant force. At a point when the crate is 3.0 m above the surface of Earth it is moving up with speed 6.0 m/s. Neglecting air resistance, determine the tension in the rope which accomplishes this.

$m = 40\ \mathrm{kg}$

Crate $\uparrow$: $\Sigma F_y = ma_y$

$\Sigma F_y = \vec{T} - mg = ma_y$

$m = 40\,\mathrm{kg}$

$g = 9.8\ \mathrm{m/s^2}$

$a_y = 6\ \mathrm{m/s^2}$

F	x	y
$\vec{T}$	0	$\vec{T}$
$\vec{F}_g$	0	$-mg$

$\vec{T} = ma_y + mg$

$\vec{T} = 40\,\mathrm{kg}(6\ \mathrm{m/s^2}) + 40\,\mathrm{kg}(9.8\ \mathrm{m/s^2})$

$\vec{T} = 632\ \mathrm{N}$

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$t = 0$ $t_1 =$

$y_0 = 0\mathrm{m}$ $y_1 = 3\mathrm{m}$

$v_{0y} = 0\ \mathrm{m/s}$ $v_{1y} = 6.0\ \mathrm{m/s}$

$a_y = 6.0\ \mathrm{m/s^2}$

$\Delta y = 3\mathrm{m}$

$v_{1y}^2 = v_{0y}^2 + 2a_y \Delta y$

$(6.0\ \mathrm{m/s})^2 = (0\ \mathrm{m/s})^2 + 2a_y(3\mathrm{m})$

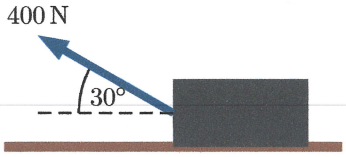
$36\ \mathrm{m^2/s^2} = 6\mathrm{m}\,a_y$

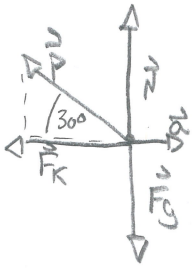
$6\ \mathrm{m/s^2} = a_y$ $a_y = 6\ \mathrm{m/s^2}$

$\vec{T} = 632\ \mathrm{N}$

Question 2

A 50 kg wooden box *moves right* along a horizontal surface. A person, attempting to slow the box, pulls on the box with a force of magnitude 400 N and which is directed 30° above the horizontal. The coefficient of kinetic friction between the box and the floor is 0.20. Determine the acceleration of the box while it is moving to the right.





$\vec{N}$ = Normal
$\vec{F}_G$ = Force of gravity
$\vec{P}$ = Pull force

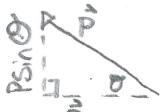
Object is moving $\therefore \Sigma F = ma$

$\vec{P} = 400N \quad \theta = 30° \quad M = 50kg$

$\Sigma f_y = 0 : \vec{N} - mg + \vec{P}\sin\theta : \vec{N} = mg - \vec{P}\sin\theta = 290N$

$\Sigma f_x = ma : -P\cos\theta - \mu_K N = ma_x$

$M = 50\,kg$
$\vec{P} = 400N$
$\mu_K = 0.20$



$\theta = 30°$

x comp $= -\vec{P}\cos\theta$
y comp $= \vec{P}\sin\theta$

Force	X	Y
$\vec{N}$	0	N
$\vec{F}_G$	0	$-mg$
$\vec{P}$	$-P\cos\theta$	$P\sin\theta$
$\vec{F}_k$	$-\mu_K N$	0

$\Sigma F_x = ma_x$

$-(400N)\cos(30) - (0.20)290N = 50kg\,(a_x)$

$-404.41N = 50\,kg\,(a_x)$

$a_x = -8.09\,m/s^2$

Acceleration $= -8.09\,m/s^2$

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Question 3

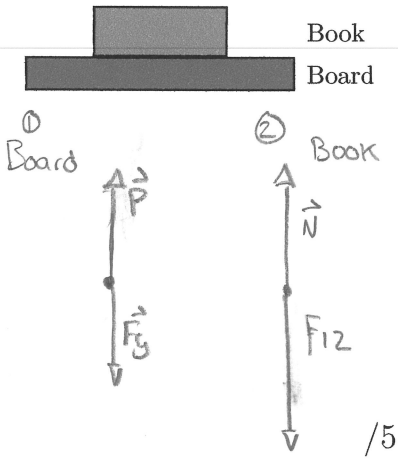
A book of mass m lies on the surface of a horizontal board. The board is raised by hand and while this happens its speed decreases; the magnitude of the acceleration is less than g. Throughout the process, the book is in contact with the board. Which of the following (choose one) is true regarding the magnitude of the normal force, n, exerted by the board on the book?

i) $n = 0$

ii) $n = mg$

iii) $n > mg$

iv) $0 < n < mg$



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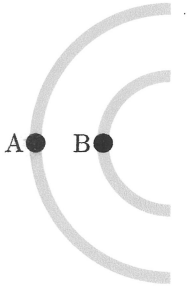
Question 4

Two cars travel on a rough horizontal surface at the same speed. Both follow circular curves while cornering with B having a smaller radius than A. The diagram illustrates this viewed from above, with the cars going clockwise.



a) Which of the following (choose one) is true regarding the magnitude of the acceleration of A, a_A, versus that of B, a_B?

i) $a_A = a_B = 0$

ii) $a_A = a_B \neq 0$

iii) $a_A > a_B$

iv) $a_A < a_B$

b) Which of the following (choose one) is true?

i) The friction force on A is the same as that on B.

ii) The friction force on A larger than that on B.

iii) The friction force on A smaller than that on B.

iv) There is no friction force on either car.

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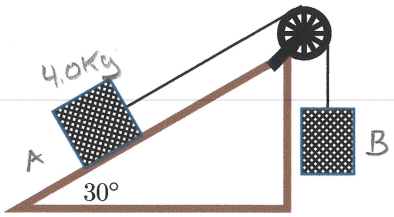
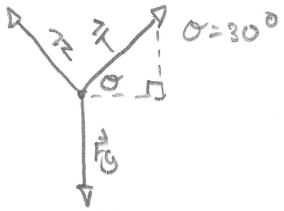
Question 5

Two blocks are connected by a string, which runs over a pulley. A 4.0 kg block is on a frictionless ramp which is inclined at an angle of 30° to the horizontal. The string connected to the block on the ramp runs parallel to the ramp. Determine the mass of the suspended block needed to keep both blocks at rest.

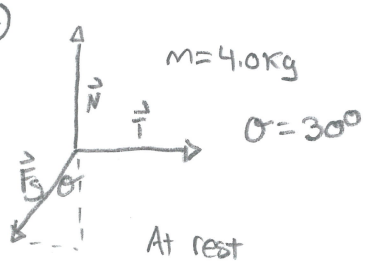


Blocks at rest : $\Sigma F = 0$



$m = 2.0\ kg$

(A)



(B)

(A)

F	X	Y
$\vec{N}$	0	N
$\vec{T}$	$\vec{T}$	0
$\vec{F}_G$	$-mg\sin\theta$	$-mg\cos\theta$

$\Sigma F_y = 0$

$\Sigma F_x = 0$

$g = 9.8\ m/s^2$ $\theta = 30$

$m = 4.0\ kg$

(A)

$\Sigma_y = 0 : \vec{N} - mg\cos\theta = 0 : \vec{N} = mg\cos\theta \approx 33.95N$

$\Sigma_x = 0 : \vec{T} - mg\sin\theta = 0 : \vec{T} = mg\sin\theta \approx 19.6N$

$\vec{T} = 19.6\ N$

(B)

F	X	Y
$\vec{T}$	0	$\vec{T}$
$\vec{F}_G$	0	$-mg$

(B) $\Sigma F_y = 0$

$\vec{T} - mg = 0 : \vec{T} = mg$

$(\vec{T} = 19.6N) : 19.6N = m(9.8\ m/s^2)$

$m = 2\ kg$

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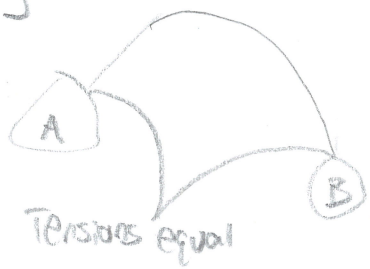
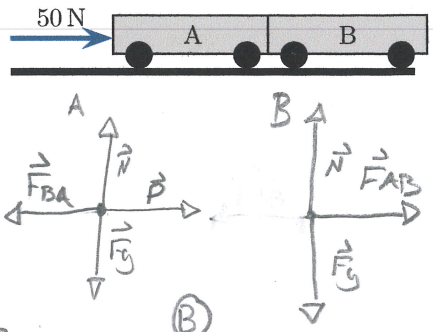


Question 6

Two carts are in contact while on a horizontal frictionless surface. Cart A has a smaller mass than cart B. Someone pushes horizontally to the right on cart A with force 50 N. Which of the following (choose one) is true?



i) The force that A exerts on B is less than 50 N.

ii) The force that A exerts on B is more than 50 N.

iii) The force that A exerts on B is exactly 50 N.

Explain your answer.

Entire system: $\sum F = m_{Both} a$

$50N = m_{Both} a$

$a = \frac{50N}{m_{Both}}$

(A) $\sum_x$

(B) $\sum_x : \vec{F}_{AB} = ma$

$A_a = B_a$

$m_B > m_A$

$\vec{F}_{AB} = m_{Bigger} a$; Larger force

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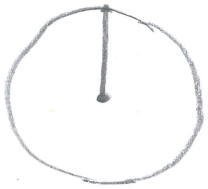
Question 7

A 0.100 kg ball swings *in a vertical circle* at the end of a string with length 0.80 m. The ball maintains a constant speed of 4.0 m/s throughout its motion.

a) Determine the tension in the string when the ball is at its highest point.



$m = 0.100\ kg$

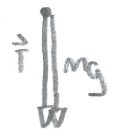
$R = 0.80\ m$

$V = 4.0\ m/s$

$a = \frac{v^2}{r}$

$a = \frac{(4.0\ m/s)^2}{0.80\ m} = 20\ m/s^2$

FBD



$\sum_y = -ma_y$

$-\vec{T} - mg = -ma_y \quad : \quad \vec{T} = ma_y - mg$

$\vec{T} = +ma_y - mg$

$\vec{T} = 0.100\ kg(20\ m/s^2) - 0.100\ kg(9.8\ m/s^2)$

$\vec{T} = 2 - 0.98$

$\vec{T} = 1.02\ N$

$\vec{T} = 1.02\ N$

Question 7 continued ...

b) Determine the tension in the string when the ball is at its lowest point.

$\Sigma_y = ma_y$

$\vec{T} - mg = ma_y$

$\vec{T} = ma_y + mg$

$\vec{T} = 2.98\,N$

$m = 0.1\,kg$

$a = 20\,m/s^2$

$g = 9.8\,m/s^2$

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